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BEYER WEAVER & THOMAS LLP
P.O. BOX 70250
OAKLAND, CA 94612-0250

EXAMINER	
PHAM, THANHHA S	

ART UNIT	PAPER NUMBER
2813	

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Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	10/690,492	LEVY ET AL.	
	Examiner	Art Unit	
	Thanhha Pham	2813	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *30 August 2004*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-50* is/are pending in the application.

4a) Of the above claim(s) *12-16,23,24,35,36 , 38 and 47-50* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-11,18-22,25-32,37 and 39-46* is/are rejected.

7)☒ Claim(s) *17,33 and 34* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *10/20/03, 8/6/04*. 8/30/04
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Election/Restrictions

1. Restriction to one of the following inventions is required under 35 U.S.C. 121:

I. Claims 1-46, drawn to a method of forming a tungsten nitride layer comprising depositing a gas phase reducing agent onto the substrate to form a layer of reducing agent on the substrate; exposing the layer of reducing agent to a tungsten containing precursor to form a tungsten layer; exposing the tungsten layer to a nitriding agent to form the tungsten nitride layer; and repeating to form one or more cycles to complete formation of the tungsten nitride layer, classified in class 438, subclass 763.

II. Claims 47-50, drawn to a method of forming a tungsten nitride layer on a substrate comprising depositing one or more layers of pulsed deposition tungsten on the semiconductor wafer, depositing one or more layers of pulsed deposition tungsten nitride on one more of tungsten, and optional repeating to generate either a bilayer of W-WN or a multilayer structure of multiple tungsten and tungsten nitride layers, classified in class 438, subclass 646.

The inventions are distinct, each from the other because of the following reasons:

Inventions I and II are unrelated. Inventions are unrelated if it can be shown that they are not disclosed as capable of use together and they have different modes of

operation, different functions, or different effects (MPEP § 806.04, MPEP § 808.01). In the instant case the different inventions have different modes of operation and different effects: The invention I is drawn to a method comprising forming a tungsten nitride layer comprising depositing a gas phase reducing agent onto the substrate to form a layer of reducing agent on the substrate; exposing the layer of reducing agent to a tungsten containing precursor to form a tungsten layer; exposing the tungsten layer to a nitriding agent to form the tungsten nitride layer; and repeating to form one or more cycles to complete formation of the tungsten nitride layer. The invention II is drawn to a method comprising depositing one or more layers of pulsed deposition tungsten on the semiconductor wafer, depositing one or more layers of pulsed deposition tungsten nitride on one more of tungsten, and optional repeating to generate either a bilayer of W-WN or a multilayer structure of multiple tungsten and tungsten nitride layers.

Because these inventions are distinct for the reasons given above and have acquired a separate status in the art as shown by their different classification, restriction for examination purposes as indicated is proper.

Because these inventions are distinct for the reasons given above and the search required for Group I is not required for Group II, restriction for examination purposes as indicated is proper.

Because these inventions are distinct for the reasons given above and have acquired a separate status in the art because of their recognized divergent subject matter, restriction for examination purposes as indicated is proper.

2. The invention I of this application contains claims directed to the following patentably distinct species of the claimed invention:

a. Species Ia, drawn to forming a metallic tungsten layer on the tungsten nitride layer to form a gate electrode comprised of the tungsten nitride layer together with the metallic tungsten layer.

b. Species Ib, drawn to forming a metallic tungsten layer on the tungsten nitride layer to form a capacitor electrode comprised of the tungsten nitride layer together with the metallic tungsten layer.

c. Species Ic, drawn to forming a metallic tungsten plug on the tungsten nitride layer to form a tungsten interconnect wherein the tungsten nitride layer serves as at least one of an adhesion layer, a diffusion barrier layer and a nucleation layer for subsequent tungsten deposition.

d. Speccies Id, drawn to forming copper on the tungsten nitride layer.

Applicant is required under 35 U.S.C. 121 to elect a single disclosed species for prosecution on the merits to which the claims shall be restricted if no generic claim is finally held to be allowable. Currently, claims 1 and 28 are generic.

Applicant is advised that a reply to this requirement must include an identification of the species that is elected consonant with this requirement, and a listing of all claims readable thereon, including any claims subsequently added. An argument that a claim is allowable or that all claims are generic is considered nonresponsive unless accompanied by an election.

Upon the allowance of a generic claim, applicant will be entitled to consideration of claims to additional species which are written in dependent form or otherwise include all the limitations of an allowed generic claim as provided by 37 CFR 1.141. If claims are added after the election, applicant must indicate which are readable upon the elected species. MPEP § 809.02(a).

Should applicant traverse on the ground that the species are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the species to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the inventions unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103(a) of the other invention.

3. During a telephone conversation with Jeffrey Weaven on 03/02/2005 a provisional election was made without traverse to prosecute the species Ic of the invention I, claims 1-11, 17-22, 25-34, 37 and 39-46. Affirmation of this election must be made by applicant in replying to this Office action. Claims 12-16, 23-24, 35-36, 38 and 47-50 are withdrawn from further consideration by the examiner, 37 CFR 1.142(b), as being drawn to a non-elected invention.

4. Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be amended in compliance with 37 CFR 1.48(b) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. Any amendment of inventorship must be accompanied by a request under 37 CFR 1.48(b) and by the fee required under 37 CFR 1.17(i).

Oath/Declaration

5. Oath/declaration filed on 02/06/2004 has been considered.

Claim Rejections - 35 USC § 112

The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

6. Claims 32 and 43 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

► With respect to claim 32, it is not clear how step (c) "exposing the layer of reducing agent to tungsten containing precursor to form a tungsten layer" can be performed prior to step (b) "depositing a gas phase reducing agent onto the substrate to form a layer of reducing agent on the substrate" – it is unclear how the layer of reducing agent can be exposed to tungsten containing precursor when the layer of reducing agent is not yet formed first by step (b).

► With respect to claim 43, the scope of the claim is vague and indefinite. It is not clear that pulsed nuclear layer (PNL) tungsten and CVD tungsten are actually deposited or not -- it not clear what "at zero, one or more stations in the reactor" means. In addition, it is not clear where the pulsed nuclear layer (PNL) tungsten and CVD tungsten are deposited – on sidewall of station? Or which location on the substrate. Moreover, "the reactor" lacks antecedent basis.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

7. **Claim 32, as being best understood, are rejected under 35 U.S.C. 102(b) as being anticipated by Elers et al. [WO 01/27347].**

Elers et al. (fig. 1, text pages 1-16) discloses the claimed method of forming a tungsten nitride layer on a substrate comprising steps of:

(a) position the substrate in the deposition chamber (page 6 lines 17-23);

(c) depositing a tungsten containing precursor onto the substrate to form a layer of tungsten containing compound (fig 1, page 6 lines 17-23, page 10 lines 20-31, page 11 lines 5-7, page 15 lines 32-34 and page 16 lines 1-23);

(b) exposing the layer of tungsten containing compound to a gas phase reducing agent to reduce said layer of tungsten containing compound to a tungsten layer (fig 1, page 6 lines 17-23, page 11 lines 7-21, page 12 lines 14-34, page 13 lines 1-31, page 14 lines 1-5, page 15 lines 32-34 and page 16 lines 1-23);

(d) exposing the tungsten layer to a nitriding agent to form a first portion of the tungsten nitride layer (fig 1, page 6 lines 17-23, page 14 lines 7-24, page 15 lines 32-34 and page 16 lines 1-23); and

(e) repeating steps (c) to (d) for one or more cycles to complete formation of the tungsten nitride layer (page 16 lines 13-18).

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

8. Claims 1-11, 17-22, 25-31, 37, 39-43 and 45-46 rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuse et al. [US 6,861,356] in view of Lee et al. [US 6,635,965].

► With respect to claims 1, 4, 28-29 and 31, Matsuse et al (figs 5-12,cols 1-23) discloses a method of forming a tungsten nitride layer on a substrate comprising:

forming a tungsten layer onto the substrate (col 10 lines 4-17);

exposing the tungsten layer to a nitriding agent to form a first portion of the tungsten nitride layer; and

performing/repeating forming the tungsten layer and exposing the tungsten layer to nitriding agent for one or more cycles to complete formation of the tungsten nitride layer wherein the additional cycles each comprise contact with reducing agent, tungsten containing precursor and nitriding agent.

Matsuse et al fails to discloses forming the tungsten layer by: depositing a gas phase boron-containing agent of borane to form a boron-containing sacrifical layer on

the substrate and exposing the boron-containing sacrificial layer to a tungsten containing precursor to form the tungsten layer.

However, Lee et al (cols 1-9) discloses forming the tungsten layer by: depositing a gas phase boron-containing agent of borane to form a boron-containing sacrifical layer on the substrate (pulsed nucleation process using B2H6, col 2 lines 45--62,col 3 lines 1-4, col 4 lines 19-22 & 52-54) and exposing the boron-containing sacrificial layer to a tungsten containing precursor to form the tungsten layer (col 4 lines 24-27 and col 5 lines 11-28).

Therefore, at the time of invention, it would have been obvious for those skilled in the art to modify process of Matsuse et al by depositing the gas phase boron-containing agent and exposing the boron-containing sacrificial layer to the tungsten containing precursor as being claimed, per taught by Lee et al, to form the tungsten layer with improved conformal and stepcoverage for providing a better tungsten nitride in subsequent step of nitriding the tungsten layer.

► With respect to claims 2-4, Matsuse et al. (fig 6D, col. 5 lines 2-7) discloses the tungsten nitride layer (14) is deposited on at least a portion of exposed dielectric layer (8) on the substrate partially fabricated semiconductor device .

► With respect to claim 5, the claimed thickness of boron-containing sacrificial layer is considered to involve routine optimization while has been held to be within the level of ordinary skill in the art. As noted in In re Aller 105 USPQ233, 255 (CCPA 1955)., the selection of reaction parameters such as temperature and concentration would have been obvious.

"Normally, it is to be expected that a change in temperature, or in concentration, or in both, would be an unpatentable modification. Under some circumstances, however, changes such as these may be impart patentability to a process if the particular ranges claimed produce a new and unexpected result which is different in kind and not merely degree from the results of the prior art...such ranges are termed "critical ranges and the applicant has the burden of proving such criticality... More particularly, where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation."

See also In re Waite 77 USPQ 586 (CCPA 1948); In re Scherl 70 USPQ 204 (CCPA 1946); In re Irmscher 66 USPQ 314 (CCPA 1945); In re Norman 66 USPQ 308 (CCPA 1945); In re Swenson 56 USPQ 372 (CCPA 1942); In re Sola 25 USPQ 433 (CCPA 1935); In re Dreyfus 24 USPQ 52 (CCPA 1934).

► With respect to claim 6, Matsuse et al. and Lee et al. discloses the tungsten containing precursor is WCl_6, WF_6, $W(CO)_6$ or a combination thereof.

► With respect to claim 7, Matsuse et al. and Lee et al. discloses the nitriding agent is N_2,NH_3, NF_3, N_2F_6 or a combination thereof.

► With respect to claim 8, Matsuse et al. and Lee et al. discloses performing a gas purge after at least one of depositing the gas phase boron containing agent, forming the tungsten layer and exposing the tungsten layer to a nitriding agent to form a first portion of the tungsten nitride layer.

► With respect to claims 9, 25 and 37, Matsuse et al. (figs 6's, col 4 lines 30-65 and col 5 lines 38-47) teaches forming the metallic tungsten layer/metallic tungsten plug (16, fig 6F) on the tungsten nitride layer (16).

► With respect to claim 10-11, CVD and pulse nucleation layer (atomic layer deposition) process are known technique for depositing metallic tungsten. See Matsuse et al. (col 15 lines 22-26 & 53-54) and Lee et al (cols 1-7) as an evidences showing that the metallic tungsten can be deposited by CVD or ALD

► With respect to claim 18-19, Mutsuse et al. discloses providing a dopant (e.g. nitrogen) to the tungsten nitride layer.

► With respect to claim 20, Matsuse et al. fails to discloses pretreating the substrate by at least one of an annealing operation and a plasma etch prior to depositing the gas phase boron-containing agent onto the substrate. However, Lee et al teaches pretreating the substrate by annealing operation (see Lee et al, col 4 lines 12-14) before depositing the gas phase boron-containing agent onto the substrate. Therefore, at the time of invention, it would have been obvious for those skilled in the art to pretreat the substrate prior to depositing the gas phase boron-containing agent in the process of Matsuse et al in view of Lee et al to provide an appropriation temperature condition for forming the tungsten layer to fabricating the tungsten nitride layer.

► With respect to claims 21-22 and 30, reducing agent comprising silicon hydride (or silane) that does not include boron containing agent is a known reducing agent for forming the tungsten layer in fabricating the tungsten nitride. Selection of a known material based on its suitability for its intended use supported a prima facie obviousness

determination in Sinclair & Carroll Co. v. Interchemical Corp., 325 U.S. 327, 65 USPQ 297 (1945) "Reading a list and selecting a known compound to meet known requirements is no more ingenious than selecting the last piece to put in the last opening in a jig-saw puzzle." 325 U.S. at 335, 65 USPQ at 301. See also In re Leshin, 227 F.2d 197, 125 USPQ 416 (CCPA 1960) (selection of a known plastic to make a container of a type made of plastics prior to the invention was held to be obvious). See Matsuse et al. that uses the SiH4 as reducing agent to form the tungsten layer.

► With respect to claim 27, Matsuse et al. (col. 11 lines 53-63 and col. 13 lines 22-28) discloses the tungsten containing precursor and the nitriding agents are delivered in an inert carrier gas or a mixture of inert gas with N2 or H2. Lee et al. (col 4 lines 52-67 and col 5 lines 1-42) discloses the boron containing agent and the tungsten containing precursor are delivered in an inert carrier gas or a mixture of inert gas with N2 or H2. Therefore, at the time of invention, it would have been obvious for those skilled in the are to use the carrier gas as being claimed to the boron-containing agent, the tungsten containing precursor and the nitriding agent in the process of Matsuse et al in view of Lee et al to control flow rate and reaction conditions in the process of depositing the tungsten nitride.

► With respect to claims 39 and 43, Lee et al (figs 4-5, cols 7-8) discloses using a multi-station apparatus to perform depositing the boron-containing agent in a different station to the station for exposing the tungsten containing precursor for forming the tungsten layer. Therefore, at the time of invention, it would have been obvious for those skilled in the art to use the multi station apparatus to practice steps for depositing the

tungsten nitride layer as being claimed in the process of Matsuse et al in view of Lee et al to provide a better control depositing process wherein parameters to control substeps used in depositing the tungsten nitride can be independently optimized or controlled.

► With respect to claims 40-42, Matsuse et al. (col. 11 lines 53-60) discloses exposing the plasma for nitridation in the process of forming the tungsten nitride (the nitridation being performed after forming the tungsten layer). Matsuse et al. also shows using RF plasma or remoted plasma for nitridation process has been known in the art (see Matsuse et al., col 14 lines 35-53, col 19 lines 18-19).

► With respect to claim 45, Lee et al. (col 4 lines 42-51) discloses passivating the substrate by mean of one or more of following: (a) hydrogen exposure; (b) exposure to a remote H/H_2 plasma; (c) exposure to direct H/H_2 or $Ar/H/H_2$ or a RF plasma; (d) exposure to WF_6; (e) exposure to H_2 or H/H_2 plasma and NH_3 in series or simultaneously; and (f) exposure to oxygen. Therefore, at the time of invention, it would have been obvious for those skilled in the art to passivate the substrate as being claimed in the process of Matsuse et al in view of Lee et al to promote the growth of the tungsten layer (see Lee et al, col 4 lines 42-51) for fabricating the tungsten nitride

► With respect to claim 46, Matsuse et al shows a module for tungsten nitride deposition is vacuum integrated with a module dedicated for pulse nucleation of tungsten or CVD of tungsten.

9. Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuse et al. [US 6,861,356] in view of Lee et al [US 6,635,965] as applied to claim 25 above, in further view of Chen et al [US 6,607,976].

Matsuse et al. in view of Lee et al. substantially discloses the claimed method but does not teach depositing a titanium layer prior to formation of the tungsten nitride layer.

However, Chen et al teaches depositing the titanium layer prior to forming the tungsten nitride layer for improve adhesion characteristic of the tungsten nitride layer.

Therefore, at the time of invention , it would have been obvious for those skilled in the art to modify process of Matsuse et al in view of Lee et al by forming the titanium layer as being claimed, per taught by Chen et al, to improve adhesion characteristics of the tungsten nitride layer.

10. Claim 44 is rejected under 35 U.S.C. 103(a) as being unpatentable over Matsuse et al [US 6,861,356] in view of Lee et al. [US 6,635,695] as applied to claim 28 above, and further in view of Yoon et al [US 6,740,585].

Matsuse et al in view of Lee et al substantially discloses the claimed method except teaching using a dedicated tungsten module with one or more deposition stations wherein the dedicated tungsten nitride module contains a wafer preheat station and a substrate preclean station wherein the substrate preclean station provides features for reactive preclean that makes use of a fluorine base chemistry generated by dissociation of a fluorine containing reagent using a inductively coupled plasma; and wherein the substrate preclean station or another station in the tungsten nitride deposition module processes features for passivating the substrate after the substrate precleaning.

However, Yoon et al. discloses a dedicated tungsten module (figure 1) with one or more deposition stations wherein the dedicated tungsten nitride module contains a

wafer preheat station (41 or 43) and a substrate preclean station (42 or 36) wherein the substrate preclean station provides features for reactive preclean that makes use of a fluorine base chemistry generated by dissociation of a fluorine containing reagent using a inductively coupled plasma (col 13 lines 6-33); and wherein the substrate preclean station or another station in the tungsten nitride deposition module (preclean station) processes features for passivating the substrate (exposure to a plasma of inert gas, a reducing gas such as hydrogen or ammonia) after the substrate precleaning .

Therefore, at the time of invention, it would have been obvious for those skilled in the art to modify process of Matsuse et al. in view of Lee et al. by depositing the tungsten nitride in the dedicated tungsten nitride module as being claimed, per taught by Yoon et al, to prevent contamination problem conveniently when fabricating the tungsten nitride.

11. Claims 1-8, 18-19, 27-29, 31, 43 and 45 are rejected under 35 U.S.C. 103(a) as being unpatentable over Elers et al. [WO 01/27347].

► With respect to claims 1, 4, 28-29 and 31, Elers et al. (fig. 1, text pages 1-16) discloses a method of forming a tungsten nitride layer on a substrate comprising:

positioning the substrate in a deposition chamber;

forming a tungsten layer on a substrate by using a gas phase boron-containing agent of borane to reduce a layer of tungsten compound wherein said layer of tungsten compound being formed by depositing the tungsten containing precursor onto the substrate ;

exposing the tungsten layer to a nitriding agent to form a first portion of the tungsten nitride layer;

repeating forming the tungsten layer and exposing the tungsten layer to a nitriding agent for one or more cycles to complete formation of the tungsten nitride layer wherein the additional cycles each comprise contact with reducing agent, tungsten containing precursor and nitriding agent.

Being different to the claimed invention, Elers et al. forms the tungsten layer by depositing the tungsten containing precursor then using the gas phase boron-containing agent of borane to reduce layer of tungsten compound to the tungsten layer. Elers et al uses the same kinds of gas phase reducing agent and tungsten containing precursor as the claimed invention to form the tungsten layer. Elers et al. fails to disclose forming the tungsten layer by: depositing a gas phase boron-containing agent of borane to form a boron-containing sacrifical layer on the substrate and exposing the boron-containing sacrificial layer to a tungsten containing precursor to form the tungsten layer. The sequence of using the tungsten containing precursor and the gas phase boron-containing agent of borane to form the tungsten layer of Elers et al. is different to the sequence of using the tungsten containing precursor and the gas phase boron-containing agent of borane to form the tungsten layer of the claimed invention.

However, the claimed invention is still obvious over Elers et al. since selection of any order of performing process steps is prima facie obvious in the absence of new or unexpected results. See In re Burhans, 154 F.2d 690, 69 USPQ 330 (CCPA 1946). See also In Ex parte Rubin , 128 USPQ 440 (Bd. App. 1959) (Prior art reference

disclosing a process of making a laminated sheet wherein a base sheet is first coated with a metallic film and thereafter impregnated with a thermosetting material was held to render prima facie obvious claims directed to a process of making a laminated sheet by reversing the order of the prior art process steps.); In re Gibson, 39 F.2d 975, 5 USPQ 230 (CCPA 1930) (Selection of any order of mixing ingredients is prima facie obvious.).

► With respect to claims 2-3, Elers et al. (page 1 lines 18-24, page 8 lines 21-28) discloses forming the tungsten nitride layer on the substrate wherein the substrate is partially fabricated semiconductor device wherein the tungsten nitride layer is deposited on at least a portion of exposed dielectric of the partially fabricated semiconductor device.

► With respect to claim 5, the claimed thickness of boron-containing sacrificial layer is considered to involve routine optimization while has been held to be within the level of ordinary skill in the art. See In re Aller 105 USPQ233, 255 (CCPA 1955); *In re Waite 77 USPQ 586 (CCPA 1948); In re Scherl 70 USPQ 204 (CCPA 1946); In re Irmscher 66 USPQ 314 (CCPA 1945); In re Norman 66 USPQ 308 (CCPA 1945); In re Swenson 56 USPQ 372 (CCPA 1942); In re Sola 25 USPQ 433 (CCPA 1935); In re Dreyfus 24 USPQ 52 (CCPA 1934).*

► With respect to claim 6, Elers et al. (page 10 lines 20-31) discloses the tungsten containing precursor is WCl_6, WF_6, $W(CO)_6$ or a combination thereof.

► With respect to claim 7, Elers et al. (page 14 lines 7-24) discloses the nitriding agent is N_2,NH_3, NF_3, N_2F_6 or a combination thereof.

► With respect to claim 8, Elers et al. (page 7 lines 13-26, page 16 lines 6-11) discloses performing a gas purge after at least one of depositing the gas phase boron containing agent, forming the tungsten layer and exposing the tungsten layer to a nitriding agent to form a first portion of the tungsten nitride layer.

► With respect to claim 18-19, Elers et al. discloses providing a dopant (e.g. nitrogen) to the tungsten nitride layer.

► With respect to claim 27, Elers et al. (page 6 lines 32-34 and page 7 lines 1-26) discloses each of the boron-containing agent, the tungsten containing precursor and the nitriding agent are delivered in an inert carrier gas or in a mixture of inert gas with N_2 or H_2 (e.g. N_2).

► With respect to claim 45, Elers et al. (page 16 lines 6-10) passivates the substrate by mean of one or more of following: (a) hydrogen exposure; (b) exposure to a remote H/H_2 plasma; (c) exposure to direct H/H_2 or $Ar/H/H_2$ or a RF plasma; (d) exposure to WF_6; (e) exposure to H_2 or H/H_2 plasma and NH_3 in series or simultaneously; and (f) exposure to oxygen [Elers et al. passivates the substrate by mean of exposure to WF_6].

12. Claims 9-11, 21-22, 25, 30, 37, 40-42 are rejected under 35 U.S.C. 103(a) as being unpatentable over Elers et al. [WO 01/273347] as applied to claims 1 and 28 above, in view of Matsuse et al. [US 6,861,356].

► With respect to claims 9-11, 25 and 37, Elers et al. substantially discloses the claimed method except teaching **(1)** forming a metallic tungsten layer/metallic tungsten plug on the tungsten nitride layer to form a tungsten interconnect wherein the tungsten

ntirde layer serves as at least one of an adhesion layer, a diffusion layer and a nucleation layer for subsequent tungsten deposition **(2)** wherein the metallic tungsten layer is deposited by CVD or pulse nucleation layer process.

Regarding to **(1)**, Matsuse et al. (figs 6's, col 4 lines 30-65 and col 5 lines 38-47) teaches forming the metallic tungsten layer/metallic tungsten plug (16, fig 6F) on the tungsten nitride layer (14). Therefore, at the time of invention, it would have been obvious for those skilled in the art to modify process of Elers et at by forming the metallic tungsten layer/plug as being claimed, per taught by Matsuse et al. to provide a metal interconnect as being needed in a device.

Regarding to **(2)**, CVD and pulse nucleation layer (atomic layer deposition) process are known technique for depositing metallic tungsten. See Matsuse et al. (col 15 lines 22-26 & 53-54) as an evidence showing that the metallic tungsten can be deposited by CVD or ALD. Therefore, at the time of invention, it would have been obvious for those skilled in the art to modify process of Elers et al. by using CVD or pulsed nucleation layer process as known method as taught by Matsuse et al to deposit the metallic tungsten layer/plug to form metal interconnection in the device.

► With respect to claims 21-22 and 30, reducing agent comprising silicon hydride (or silane) that does not include boron containing agent is a known reducing agent for forming the tungsten layer in fabricating the tungsten nitride. Selection of a known material based on its suitability for its intended use supported a prima facie obviousness determination in Sinclair & Carroll Co. v. Interchemical Corp., 325 U.S. 327, 65 USPQ 297 (1945) "Reading a list and selecting a known compound to meet known

requirements is no more ingenious than selecting the last piece to put in the last opening in a jig-saw puzzle." 325 U.S. at 335, 65 USPQ at 301. See also In re Leshin, 227 F.2d 197, 125 USPQ 416 (CCPA 1960) (selection of a known plastic to make a container of a type made of plastics prior to the invention was held to be obvious). See Matsuse et al. as an evidence that uses the SiH4 as reducing agent to form the tungsten layer. Therefore, at the time of invention, it would have been obvious for those skilled in the art, in view of Matsuse et al, to select the claimed reducing agent as known material to form the tungsten layer in the process of Elers et al. for fabricating the tungsten nitride.

► With respect to claims 40-42, Elers et al. substantially discloses the claimed method but does not expressly teach exposing a plasma containing Ar, N2 , H2 NH3 or any combination thereof wherein the plasma is a RF plasma or remoted plasma after forming the tungsten layer, forming the first portion of the tungsten nitride layer or completing formation of the tungsten nitride layer.

However, Matsuse et al. (col. 11 lines 53-60) discloses exposing the plasma for nitridation in the process of forming the tungsten nitride (the nitridation being performed after forming the tungsten layer). Matsuse et al. also shows using RF plasma or remoted plasma for nitridation process has been known in the art (see Matsuse et al., col 14 lines 35-53, col 19 lines 18-19).

Therefore, at the time of invention, it would have been obvious for those skilled in the art to modify process of Elers et al by exposing the plasma as being claimed (e.g. after forming the tungsten layer) as taught by Matsuse et al. to improve the process of

forming the tungsten nitride wherein nitriding the tungsten layer can be performed efficiently by the usage of the known plasma source of RF plasma or remote plasma.

13. Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Elers et al. [WO 01/27347] in view of Matsuse et al. [US 6,861,356] as applied to claim 25 above, in further view of Chen et al. [US 6,607,976].

Elers et al. in view of Matsuse et al. substantially discloses the claimed method but does not teach depositing a titanium layer prior to formation of the tungsten nitride layer.

However, Chen et al teaches depositing the titanium layer prior to forming the tungsten nitride layer for improve adhesion characteristic of the tungsten nitride layer.

Therefore, at the time of invention , it would have been obvious for those skilled in the art to modify process of Elers et al in view of Matsuse et al by forming the titanium layer as being claimed, per taught by Chen et al, to improve adhesion characteristics of the tungsten nitride layer.

14. Claims 39, 43-44 are rejected under 35 U.S.C. 103(a) as being unpatentable over Elers et al. [WO 01/27347] as applied to claim 28, in further view of Yoon et al. [US 6,740,585].

► With respect to claims 39 and 43, as being best understood, Elers et al substantially discloses the claimed method but is silent about depositing the tungsten nitride is carried out in a multi-station reaction chamber wherein the tungsten nitride is deposited at one or more deposition stations.

However, Yoon et al. (fig 1, col. 5-2 and col 14 lines 57-64) discloses a multi-station chamber wherein the tungsten nitride can be deposited in at one or more stations (38 or 40 ,fig 1).

Therefore, at the time of invention, it would have been obvious for those skilled in the art to modify process Elers et al. by using the multi-station reaction chamber as being claimed, per taught by Yoon et al, to practice the process depositing the tungsten nitride conveniently with multi-task processing steps that can be performed at the same for time saving when fabrication device.

► With respect to claim 44, Elers et al substantially discloses the claimed method except teaching using a dedicated tungsten module with one or more deposition stations wherein the dedicated tungsten nitride module contains a wafer preheat station and a substrate preclean station wherein the substrate preclean station provides features for reactive preclean that makes use of a fluorine base chemistry generated by dissociation of a fluorine containing reagent using a inductively coupled plasma; and wherein the substrate preclean station or another station in the tungsten nitride deposition module processes features for passivating the substrate after the substrate precleaning.

However, Yoon et al. discloses a dedicated tungsten module (figure 1) with one or more deposition stations wherein the dedicated tungsten nitride module contains a wafer preheat station (41 or 43) and a substrate preclean station (42 or 36) wherein the substrate preclean station provides features for reactive preclean that makes use of a fluorine base chemistry generated by dissociation of a fluorine containing reagent using

a inductively coupled plasma (col 13 lines 6-33); and wherein the substrate preclean station or another station in the tungsten nitride deposition module (preclean station) processes features for passivating the substrate (exposure to a plasma of inert gas, a reducing gas such as hydrogen or ammonia) after the substrate precleaning .

Therefore, at the time of invention, it would have been obvious for those skilled in the art to modify process of Elers et al. by depositing the tungsten nitride in the dedicated tungsten nitride module as being claimed, per taught by Yoon et al, to prevent contamination problem conveniently when fabricating the tungsten nitride.

Allowable Subject Matter

15. Claims 17 and 33-34 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

16. The following are statements of reasons for the indication of allowable subject matter:

► Recorded Prior Art fails to disclose or suggest the combination of the process steps as recited in the base claim 1 including treating the tungsten layer created in step (b) with hydrogen or argon-hydrogen plasma before exposure to the nitriding agen in step (c) as characteristics in claim 14.

► Recorded Prior Art fails to disclose or suggest the combination of the process steps as recited in the base claim 28 including wherein one or more of reducing agent, the tungsten containing precursor, and the nitriding agent comprise a different

compound when employed to form the first portion of the tungsten nitride layer and when employed in (e) as characteristics in claim 33.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Thanhha Pham whose telephone number is (571) 272-1696. The examiner can normally be reached on Monday and Thursday 9:00AM - 9:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Carl Whitehead can be reached on (571) 272-1702. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Thanhha Pham
Patent Examiner
Patent Examining Group 2800